1-1-1984

Progress report; The Kingman disrupted zone

Lillian Morisi

June 19, 1984

Marc Loiselle
Maine Geological Survey
State House Station #22
Augusta, ME 04333

Dear Marc,

Enclosed please find a copy of the progress report concerning the rocks of "The Kingman Disrupted Zone". Please keep in mind that this is only a progress report based on field mapping and preliminary laboratory analysis. A detailed study is now in progress and is scheduled to be completed by January 1985.

I would like to extend my thanks and appreciation for your support and generosity. I am especially grateful to you for the time and effort it took to repack and ship my samples. I cannot thank you enough.

If you should have any questions concerning this report please do not hesitate to contact me at Queens College. I will, however, be in Maine at the end of July and would be more than happy to speak with you then.

Sincerely,

Lillian Morisi

Lillian Morisi
Dept. of Earth & Env. Sci.
Queens College
Flushing, N.Y. 11367

STATE OF MAINE
DEPARTMENT OF CONSERVATION
STATE HOUSE STATION 22
AUGUSTA, MAINE 04333

JOSEPH E. BRENNAN
GOVERNOR

RICHARD B. ANDERSON
COMMISSIONER

3 July 1984

Ms. Lillian Morisi
Department of Earth and
Environmental Sciences
Queens College
Flushing, NY 11367

Dear Lillian,

I am writing to acknowledge receipt of your progress report on the Kingman disrupted zone. I have not had a chance to read it thoroughly, but plan to do so as soon as time permits. At that time I may have some questions, and will let you know if I do.

I take it from your letter that you hope to have your MS thesis completed in January; when you do we would like to receive a copy for our library. If you plan to pass through the Augusta area when you come to Maine, I will make sure to have read the report in detail by then.

Good luck in your completing your thesis, and in your future geologic work.

Sincerely,

Marc Loiselle
Senior Geologist

EXPLANATION FOR PLATE 1

	Di	Intrusive Rock
DEVONIAN	DSm	Madrid Formation
	Ssf	Smalls Falls Formation
	Spm	Perry Mountain Formation
	Ssc Ss Ssl	Sangerville Formation conglomerate member ribbon limestone member
	Sw ? Spu	Waterville Formation Unnamed Pelitic Rocks
SILURIAN	SOv	Vassalboro Formation

Lithologic contacts:
(dashed where inferred)

Faults :

Exposures which exhibit intense deformation : *

1984
Progress Report
The Kingman Disrupted Zone

Lillian Morisi
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INTRODUCTION

The Kingman disrupted zone was first identified by Ludman (1982) during reconnaissance mapping in east-central Maine. It extends a distance of over 50 kilometers between Kingman and Howland, ranging in width from 2.5 to 4 km (Fig. 1). Ludman (pers. comm., 1983) defines the zone as intensely disrupted rock, both lithologically and structurally unique in its regional setting.

The Kingman zone, shown as a fault on the 1984 state map of Maine (Fig. 2), separates different stratigraphic packages on either side. To the northwest, a stratigraphic sequence well established in central Maine terminates at a low angle along this zone. This sequence includes metagraywackes, slates, and metasiltstones of the Sangerville, Waterville(?), and Madrid Formations, respectively. Rocks to the southeast include pelites assigned to the Smyrna Mills Formation and limestones of the Carys Mills(?) Formation (Ludman; pers. comm., 1983). Within the zone itself, the rocks consist of thin bedded slates and siltstones characterized by disrupted and chaotic structural features.

The present study was initiated to determine the nature of this chaotic zone and its relationship to the surrounding rocks. Several possibilities have been suggested by Ludman (pers. comm., 1983) for the role played by the Kingman zone in the evolution of the region:

1) It is the trace of a major strike-slip fault that now separates two different rock suites;

2) It is the trace of a relatively "unimportant" strike-slip fault and does not produce serious dislocation of different stratigraphic packages.

3) It is a package of incompetent rocks bounded by more competent sandstones, all deformed during regional folding;

4) It is the tightly folded nose of a large scale soft-sediment slump.

It is not possible at this time to conclusively eliminate any of these theories, or to propose new ones, because much of the important petrographic work has not yet been completed. The main objective of this report is therefore to summarize both field observations and results of preliminary laboratory studies concerning the Kingman zone and the rocks adjacent to it.

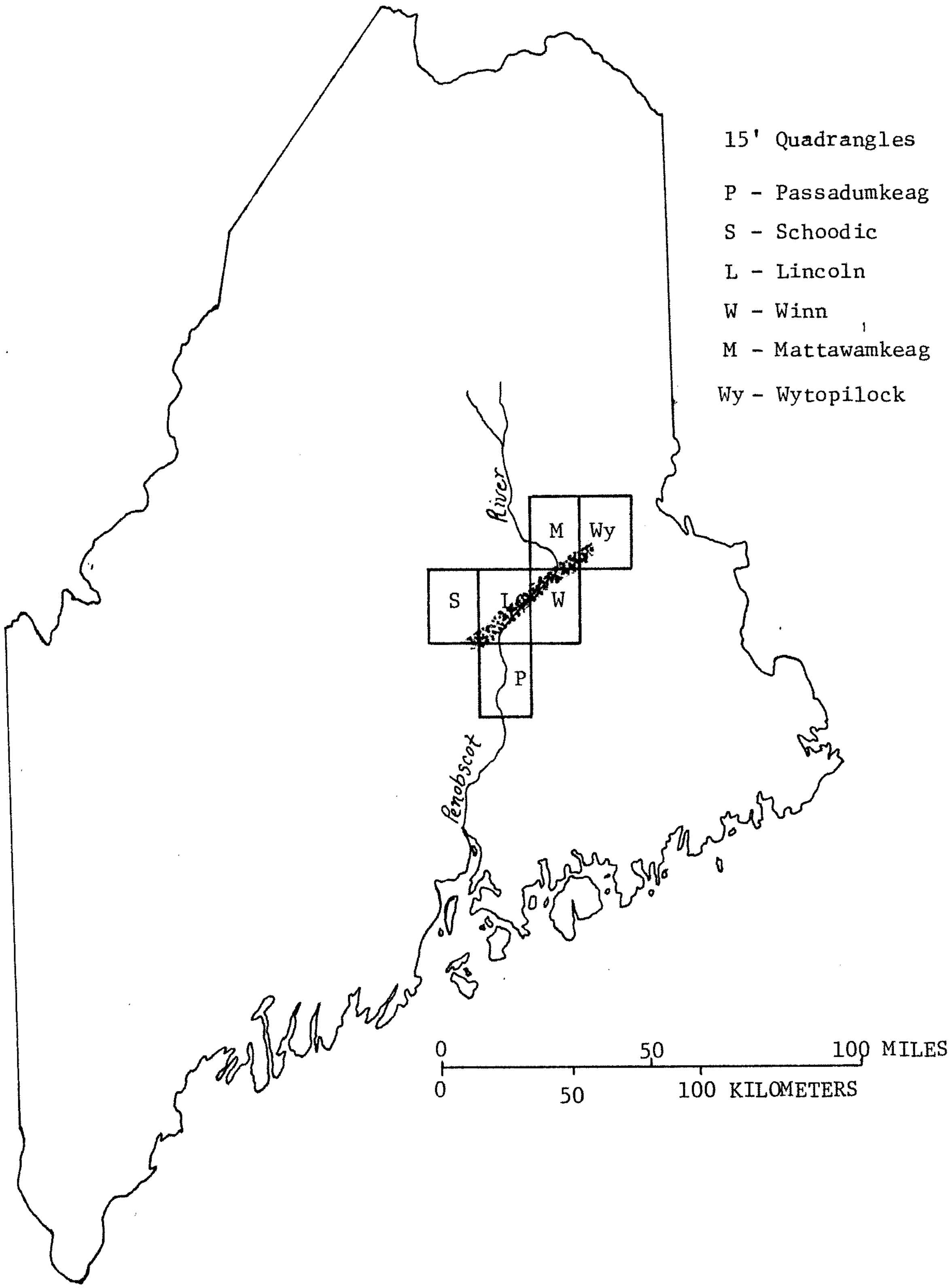

Figure 1: Location map. Kingman Disrupted Zone shown by stippled pattern.

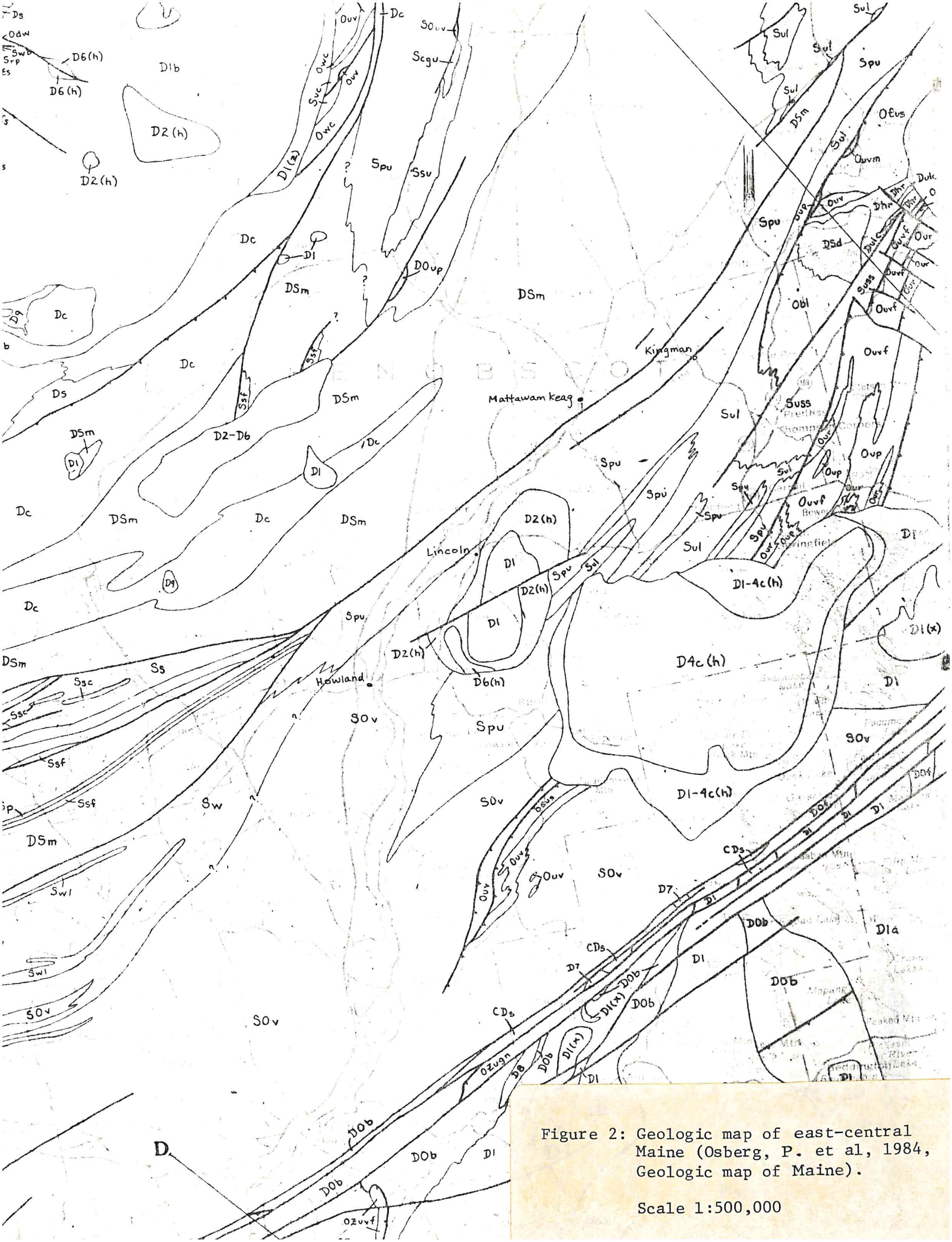

Figure 2: Geologic map of east-central Maine (Osberg, P. et al, 1984, Geologic map of Maine).

Scale 1:500,000

PREVIOUS WORK

The existence of a major north-northeast trending lineament in east-central Maine has long been debated by Barosh and others (Barosh, 1978; Barosh & O'Leary, 1977). This feature, termed the Penobscot Line, was first noted by Hobbs in 1904. The line extends a distance of over 300 kilometers from Orland to Square Lake.

Barosh & O'Leary (1978) have noted that a segment of the line follows the course of the Penobscot River from Old Town to South Lincoln and extends north, to the east of Millinocket. Within this segment, the northerly trend of the line exhibits a slight deviation from Howland to South Licoln as it follows the river valley. This deviation corresponds to a northeast trending lineament over 40 kilometers long depicted on the Landsat map of Barosh (1978, Fig. 16). It is this northeast trending topographic feature that directly corresponds to the trace of the Kingman disrupted zone.

Portions of the Sebec and Schoodic quadrangles have been examined by Newberg (1983) in an attempt to correlate recent seismic activity with evidence of post-Acadian brittle deformation. His study concentrated on the structural and topographic features noted in this area. Newberg (1983) has concluded that the topographic lineaments bear little relation to the structural features observed. The course of the Piscataquis River marks an east-west lineament that is believed to be stratigraphically controlled, while the nature of the Penobscot Line has not yet been determined (Newberg, 1983). Newberg (1983) states that evidence of post-Acadian brittle failure is lacking in this area and can be seen at only two outcrops in the vicinity of Howland. The possibility has therefore been suggested that "the Penobscot River may occupy the locus of a presently active tectonic zone" (Newberg, 1983).

METHODS

The Howland-Kingman area, covering 400 square kilometers, was mapped during a ten week period in the summer of 1983. Mapping was carried out at a scale of 1:62,500. Surface expression was examined with the aid of topographic maps, orthophotoquads, and Landsat imagery. Subsurface distribution was also noted using a Bouguer gravity map of Maine.

The standard field investigation included outcrop location, lithologic descriptions, and analysis of structural features. A suite of oriented samples was collected for petrographic examination of both lithological and structural characteristics.

BOUGUER GRAVITY MAP

Several linear features can be seen on the Bouguer gravity map of Maine (Kane & Bromery, 1966; Fig. 3). One such feature can be traced from as far south as Wayne to North Amity near the Canadian border. The gravity contours trend to the northeast and exhibit a step-like change in gradient of 8 milligals. Locally, the gravitational field across this feature is complicated by negative anomalies associated with granitic plutons.

In the study area, the gravity contours parallel the trace of the Penobscot River from Howland to Mattawamkeag, and the steep gravity gradient coincides with the trace of the Kingman disrupted zone. The step-like change in the gravity profile is constrained within a belt approximately 8 kilometers wide that contains the thinly interbedded slate and siltstone. The areas on opposite sides of the "step" are dominated by sandstones, siltstones, and slates of Silurian and Siluro-Devonian(?) age. These rocks do not differ significantly in terms of density and it is therefore unlikely that their surface distribution would be responsible for such a rapid change in the gravity field. It is believed that this gravitational pattern is a reflection of a deep crustal feature. It may well represent the contact along which two different crustal blocks have been juxtaposed.

Support for such a structural break may be found in the study of granitic plutons in central and eastern Maine. Loiselle and Ayuso (1980) have investigated the differences between these plutons based on structure, texture, and mineralogy. A more recent study by Andrews, Loiselle, & Wones (1983) relates variations in strontium and oxygen isotope ratios to source rock composition. The results of both studies indicate a division of these plutons into three separate groups: 1) the southeastern plutons (Lucerne and Lead Mountain Granites); 2) the central plutons (Bottle Lake Complex and Center Pond Pluton); 3) the northwestern plutons (Katahdin Pluton and Seboeis Complex). The northeast trending gravity step noted on the Bouguer gravity map of Maine forms the boundary between the northwestern and central plutons, while the Norumbega Fault Zone separates those to the southeast (Andrews et al, 1983). It has been suggested that these boundaries represent major crustal breaks and that the different source regions associated with these plutons have been juxtaposed by transcurrrent faulting (Andrews et al, 1983).

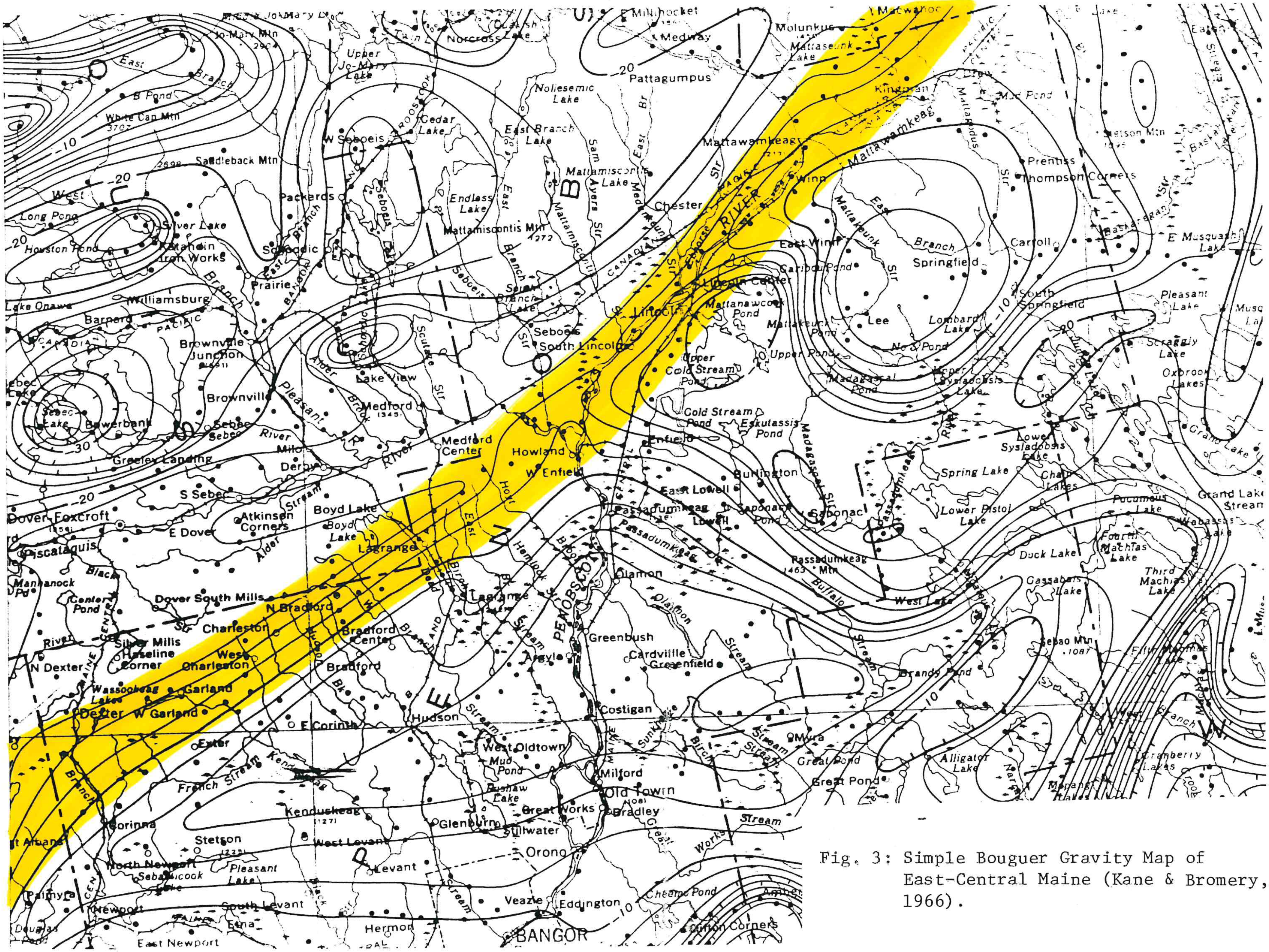

Fig. 3: Simple Bouguer Gravity Map of East-Central Maine (Kane & Bromery, 1966).

LANDSAT IMAGERY

Landsat photos of east-central Maine show a multitude of topographic lineaments in the vicinity between Howland and Kingman (Fig. 4).

The most obvious topographic features are those related to Pleistocene glaciation. A strong, northwest-southeast trending fabric can be traced throughout most of this region. East of the Mattawamkeag and Penobscot Rivers, this erosional fabric controls the configuration of many of the major lakes.

Across the Penobscot River to the west it is a north-south trending fabric which characterizes the area. These lineaments, also related to glaciation, are less strongly developed than those to the east and coincide with eskers and stream valleys depicted on the topographic maps.

Lineaments unrelated to glaciation are also defined on the Landsat photos. The most striking of these is that related to the Penobscot River valley. From Mattawamkeag to just north of Howland, the Penobscot River follows an extremely linear course which trends northeast-southwest. At either end of this segment, the course of the river experiences a rather sharp deviation in trend(Fig. 4). These sharp bends can be seen in the course of the Mattawamkeag and Piscataquis Rivers as well.

Bedrock exposures, within and around the river valleys, suggest that neither the course of flow nor the sharp bends are stratigraphically controlled. The flow of the Piscataquis River, from Schoodic Point east to Howland, was found to crosscut nearly vertical beds of limestone as well as sandstone. This is also the case for the Mattawamkeag River where it flows at an angle to beds of slate and siltstone.

Exposures which are characterized by intense deformation can be found along many of the rivers in this area but are quite common to both the Mattawamkeag and Penobscot Rivers. Such exposures often occur where these rivers experience a sharp deviation in course. It is, therefore, possible that the course of these rivers is, at least in part, structurally controlled.

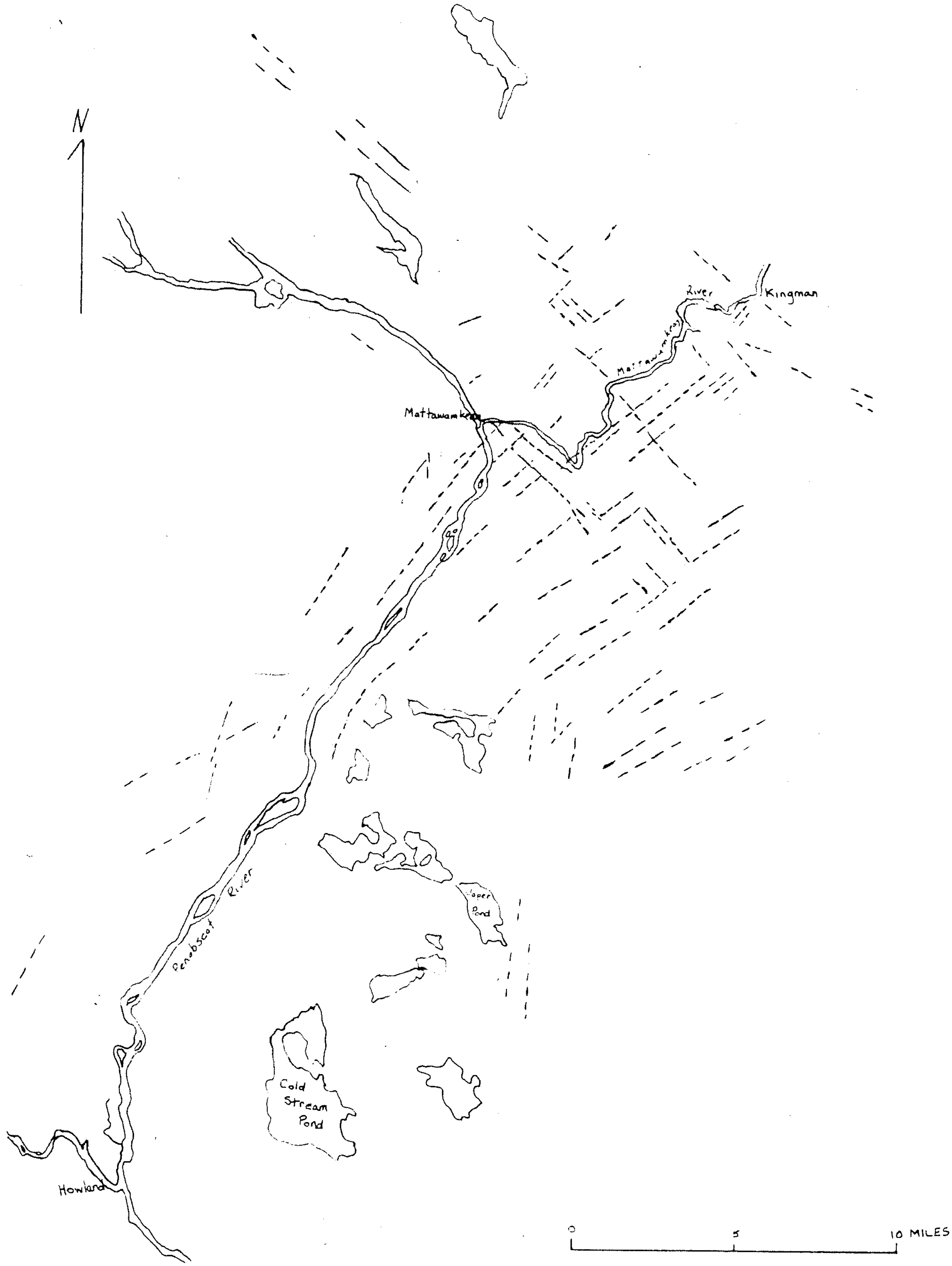

Figure 4: Landsat lineament map.

STRATIGRAPHY

The rocks of east-central Miane are characterized by a low intensity of metamorphism (Pankiwskyj et al, 1976), generally chlorite to biotie grade. Primary sedimentary structures and textures are still recognizable in many of the rocks in the study area. For simplicity, the rocks described within this report will be discussed without the prefix meta-. It should be remembered, however, that all of the rocks have been metamorphosed to at least chlorite grade.

The formations described below are those which occur within the study area. With the exception of the Vassalboro Formation,they are listed in order of age, from oldest to youngest, based on the stratigraphy accepted for use on the 1984 state map of Maine. The age of the Vassalboro has recently been revised and will, therefore be discussed last.

Unnamed pelitic rocks (Silurian)

A belt of thinly interbedded and interlaminated slates and siltstones can be traced throughout the central portion of the map area (Plate 1). This belt of unnamed rock extends from the Piscataquis River in the south to as far north as Kingman where its rocks are exposed on the banks of the Mattawamkeag River. On the 1984 Maine state map (Fig. 2), these rocks are referred to as "Silurian pelites unnamed" (Spu).

Within these rocks, the proportion of slate to siltstone is highly variable. The slates generally dominate by a ratio of 2:1 but occurrences of a 1:1 relationship are not uncommon.

The slates are mainly gray to greenish gray in color but commonly include beds of green, maroon, and black slates as well. Locally these rocks may appear as phyllites, but are nowhere found to represent any higher grade of metamorphism. Thick packages of maroon and green slate are characteristic of many exposures within this belt and would appear to serve as a useful marker horizon. Whether these slates occur as continuous beds or as discontinuous horizons is not known.

The siltstones are commonly light gray, greenish gray, and green. They tend to be slightly calcareous and in many areas highly calcareous. Fine grained sandstone is also present as interbedded layers within the slate, but for the most part, the grain size remains that of silt.

Small, discontinuous lenses of micritic limestone have been found within this belt. These lenses are, however, restricted to only two exosures, one on the Mattawamkeag River at Slewgundy Heater and the second on Medunkeunk Stream.

Along the Mattawamkeag River, at both Lower Gordon Falls and Kingman, the rocks exhibit a transposition layering which may easily be mistaken for bedding. The secondary layering tends to be thin (a few milimeters thick) and parallel to a well developed axial planar cleavage that crosscuts bedding. Microscopic analysis has not yet been completed on this secondary layering but field evidence indicates that the layers are composed of an argillaceous siltstone or fine grained sandstone and slate.

Bedding is thus not always detectable in these rocks, and bed thicknesses are difficult to estimate. The chaotic structures produced by deformation often obscure and disrupt the true nature of the beds. Where recognizable, the thickness of individual beds differ from one expoosure to the next. Slates are often found to occur in beds 3 cm thick but may range from 1 cm to over 1.5 m. The thicker of the beds are laminated with siltstones. The thickness of the siltstone beds, ranging from a few millimeters to 6 cm, generally does not exceed that of the slates.

To the south, the interbedded slates and siltstones of the Waterville formation occur on strike with this belt of unnamed pelites. This formation, as described by Pankiwskyj et al (1976), Ludman & Griffin

(1974), and Griffin (1973), is similar in both lithology and bedding style to the unnamed rocks. Horizons dominated by maroon and green slates have been noted by Griffin (1973) in the Boyd Lake, Stetson, and Pittsfield quadrangles (Pankiwskyj et al, 1976). Griffin (1973) has mapped these vari-colored slates as a separate member within the Waterville Formation, which has been informally named the Pittsfield member (Pankiwskyj et al, 1976).

Pelites assigned to the Smyrna Mills Formation have been mapped in the area to the northeast of these unnamed pelites. This formation, as described by Pavlides & Berry (1966), consists of interbedded slate and siltstone which are gray to green in color. Bedding ranges from 0.5 cm to possibly 1 meter. Maroon and black slates, as well as coarser clastics, commonly occur as thin and small lenticular layers.

The bedding style and lithology described within both the unnamed pelitic unit and the Waterville Formation bear a significant resemblance to those of the Smyrna Mills Formation, further to the north.

Sangerville Formation (Silurian)

In the southeast portion of the Schoodic 15" quadrangle a series of exposures along the Piscataquis River resemble the rocks of the Sangerville Formation in central Maine (Plate 1). These rocks consist primarily of interbedded sandstone, siltstone, and slate in highly variable proportions. Locally, horizons of polymictic conglomerate and argillaceous limestone are present.

Bed thickness within these rocks is quite variable, ranging from a few centimeters to at least 5 meters. The thicker beds are generally characterized by a coarse grained, slightly calcareous sandstone whose composition is that of a feldspathic wacke. Clasts of quartz, feldspar, slate, quartzite, and volcanic fragments have been identified in these rocks.

The slates, ranging in color from dark gray to green, also occur in thick homogeneous beds but are, for the most part, thinly interbedded with siltstone. The slates, as well as the sandstones, contain ferroan carbonate (ankerite or siderite) which weathers to hematite. The weathered surface of the rock is iron stained and speckled with small rusty red pits where this mineral is abundant.

Locally occurring within the interbedded slates and sandstones are massive, poorly graded beds of polymictic conglomerate. These beds, up to at least two meters in thickness, are similar in composition to the coarse grained sandstones. All of the clasts identified in the sandstone have been found in the conglomerate. The range in clast size from fine sand to granule is what distinguishes this rock from the sandstone. Similar horizons within the Sangerville Formation have previously been mapped in central Maine where they are referred to as the granule conglomerate member and the polymictic granule metaconglomerate member, by Ludman & Griffin (1974) and Pankiwskyj et al (1976), respectively.

The most stiking unit exposed along the Piscataquis River bears no resemblance to those previously mentioned. This unit consists of thinly interbedded micritic limestone, argillaceous siltstone, and slate. The sandstones, siltstones, and slates which dominate this area grade rather abruptly into this limestone rich unit. Within the transition zone, the siltstone layers are most abundant and range in thickness from 1 to 5 cm. With an increase in limestone the siltstone layers die out and the unit is dominated by micrite interbedded with dark gray slate. The micrite beds are 1 to 24 cm thick, with an average of 3 cm. The slates, somewhat less abundant, range in thickness from 0.5 to 10 cm, with an average of 1 cm. The actual thickness of this unit is unknown but can be estimated to at least 84 meters.

The rocks exposed along the Piscataquis River occur on strike with those of the Sangerville Formation further to the south and west in the Boyd Lake and Dover-Foxcroft quadrangles (Pankiwskyj et al, 1976). The interbedded graywackes and slates, the granule conglomerate, and the ribbon limestone, which characterize the Sangerville Formation in these regions, are the same as those found on the Piscataquis River.

Madrid Formation (Siluro-Devonian)

The rocks which characterize the northern and western portion of the map area are interbedded sandstones (60%), siltstones (15%), and slates (25%) of the Madrid Formation (Plate 1). These rocks extend at least as far north as the Penobscot/Aroostook County line and as far south as the Seboeis Stream, west of the Penobscot River.

The Madrid Formation, as seen in this area, is dominated by fine grained, calcareous sandstones. They are light gray to gray green in color but are often masked by an orange brown weathering rind. The sandstones occur, for the most part, in massive, poorly graded beds, ranging from 30 cm to 1.5 m in thickness. One of the distinguishing characteristics of these rocks is the high percentage of mica. Muscovite is present as both coarse flakes, up to 0.8 mm in length, and as fine grained particles dispersed throughout the matrix.

Interstratified with the massive sandstones are beds of dark gray to gray green slates. The thickness of the slate beds range from 5 cm to 1 m, with an approximate average of 18 cm. Siltstone laminae often occur within the slates but remain at a low proportion.

The Fall Brook Formation, as defined by Pankiwskyj et al (1976), is composed of thick bedded, slightly calcareous metasandstone and associated minor metapelite. This formation, common in west-central and central Maine, has been shown to extend as far north as the Schoodic 15' quadrangle (Pankiwskyj et al, 1976). These rocks are similar in both bedding style and lithology to those of the Madrid Fortmation. Moench et al (1982) have included the rocks of the Fall Brook Formation in their description of the eastern facies of the Madrid Formation.

Similar rocks have been mapped and described by Roy (1981) in portions of the Millinocket, Sherman, and Mattawamkeag quadrangles. These rocks, informally termed the Lawler Ridge Formation (Roy, 1981) are believed to be equivalent to those of the Madrid Formation (Roy et al, 1983).

The rocks of the Madrid Formation are similar to those of the Sangerville Formation in both composition and bedding style. The fine grained size, which tends to occur within the Madrid sandstones, is locally variable, ranging from silt to coarse sand. This range in grain size is also true for many of the rocks of the Sangerville Formation.

These two formations are distinguishable, on a regional scale, by internal members characteristic of the Sangerville Formation. The limestone rich unit, referred to as the"ribbon limestone" of the Sangerville Formation, does not occur in the Madrid. Carbonate rich beds and pods occur within portions of the Madrid Formation but are not as extensive as those in the Sangerville. It is, however, worth mentioning that in the absence of this distinctive marker horizon, the two formations may be indistinguishable.

A second factor which may prove to be a useful indicator for differentiating between these two formations is the abundance of mica. Thin section and hand sample analysis reveal a somewhat higher percentage of coarse grained muscovite in the sandstones of the Madrid Formation. This feature may not, however, always be discernible.

Vassalboro Formation (Ordovician-Silurian)

The Vassalboro Formation is confined to the southeasternmost portion of the map area in the vicinity of Howland (Plate 1). The best exposures of which are located just downstream of both the Howland and Enfield Dams.

The most abundant rock type within the Vassalboro Formation is a fine grained, calcareous sandstone (75-80%). Gray and green slates are associated with these sandstones but make up only 20-25% of the formation as seen in this area. Minor amounts of maroon slate and carbonate rich beds are confined to the rocks exposed at the Enfield Dam.

The composition of the clastic rocks is that of a quartz wacke. The grain size, although generally fine, may range from silt to medium sand. In the coarser grained rocks, clasts of quartz, feldspar, and volcanic fragments have been identified. These rocks range in color from gray to green and are often stained an orange brown on the weathered surface. The thickness of individual beds may vary but is generally quite thick, ranging from 30 cm to at least 3 m.

The slates contained within this formation are both interlaminated and interbedded with the massive sandstones. The thickness of the slate beds generally range from 5 to 30 cm.

The carbonate rich beds exposed at the Enfield Dam occur in a horizon at least 3 m thick. These rocks are white to greenish white in color and are thinly interbedded with bright green slates. The beds are generally 1 to 1.5 cm thick, although beds on the mm scale are also common. The weathered surface of these rocks is characterized by a dark reddish brown to black stain.

The rocks of the Vassalboro Formation and those of the Madrid are extremely similar. Both formations are dominated by massive sandstones interbedded with lesser amounts of slate.

In thin section, the sandstones from each of these two formations are identical in both compositon and texture. They are composed of fine to medium grained quartz in a matrix of quartz, clay, chlorite, muscovite, and carbonate. Clasts of feldspar and volcanic fragments also have been identified.

Ludman & Griffin (1974) have suggested that a correlation exists between the rocks of the Madrid and Vassalboro Formations in the Merrimack Synclinorium. Osberg (1980) has since redefined the age of the Vassalboro Formation, from Siluro-Devonian to Ordovician-Silurian, therefore arguing against the possibility of such a correlation.

It would appear that the age of the Vassalboro Formation remains to be truly defined.

MAP DISCUSSION

The distribution of lithologies as categorized into formations and unnamed rock units is shown on Plate 1. This map pattern is based, for the most part, on the presently accepted stratigraphy used in compilation of the 1984 state map of Maine.

The overall distribution of lithologies as seen on Plate 1, does not differ significantly from that shown on the 1984 Maine state map (Fig. 2). In the southern portion of the map area, minor changes have been made concerning the rocks of the Sangerville, Perry Mountain, and Smalls Falls Formations. These changes are, however, simply a matter of location and do not produce major differences in the map pattern.

In the western and northern portions of the map area, a series of faults has been defined on the 1984 state map of Maine (Fig. 2). These faults define the extent of the Kingman disrupted zone. The configuration of the faults as shown on Plate 1, is somewhat modified from those shown on the state map.

The southwesternmost portion of the map area is dominated by the rocks of the Sangerville Formation (Plate 1). These rocks are exposed along the Piscataquis River from just east of Medford to approximately 1 mile east of the Piscataquis/Penobscot County line. Horizons of polymictic granule conglomerate and ribbon limestone, which characterize the Sangerville, have been mapped as separate members within the formation.

To the northwest and southeast, the rocks of the Sangerville Formation are, in part, fault bounded against those of the Madrid and Waterville(?) Formations, respectively (Plate 1). The pattern shown here differs slightly from that shown on the 1984 state map of Maine and is based on the distribution of rock units exposed along the Piscataquis River. On the 1984 state map of Maine (Fig. 2), a conformable sequence consisting of Sangerville, Perry Mountain, and Smalls Falls is shown to exist, at least in part, along the Piscataquis River. Rocks of the Madrid Formation, which top the sequence, are mapped further to the southeast. Field mapping has shown that neither the rocks of the Perry Mountain nor those of the Smalls Falls Formations are exposed along the course of this river. They are in fact, absent from all parts of the study area between Howland and Kingman. The northerly extent of these formations is, therefore, replotted further to the south of the Piscataquis River.

The ribbon limestone member of the Sangerville Formation has also been shifted slightly eastward of the position shown on the 1984 Maine state map (Fig. 2). These rocks are exposed along the Piscataquis River approximately 0.75 miles east of the Piscataquis/Penobscot County line.

The faults which bound the Sangerville Formation in the southern portion of the map area are based on previous mapping by Pankiwskyj et al (1976) and Griffin (1973), in the Boyd Lake, Dover-Foxcroft, and Guilford quadrangles, further to the south. The rock distribution within the study area agrees with these fault boundaries and is therefore shown on Plate 1. The basis for this agreement is, for the most part, stratigraphic. The rocks of the Sangerville Formation have not been found in any part of the study area north of the exposures located on the Piscataquis River. These rocks, therefore, terminate at a low angle against those of the Madrid and Waterville(?) Formations, to the northwest and southeast, respectively. This relationship is neither structurally nor stratigraphically possible for either boundary without the existence of a major structural break.

The fault located within the Sangerville Formation is based entirely on mapping further to the south (Osberg, 1984). The extension of this fault into the Schoodic quadrangle is not suggested by any major dislocation of lithologies but may well explain the existence of disrupted rock found along the river. Since its presence does not prove to be a major contradiction to any of the features seen in this area the fault is plotted on Plate 1 as suggested by the 1984 state map of Maine (Fig. 2).

The major northeast striking fault which extends across the entire western portion of the map area (Plate 1) is both stratigraphically and structurally defined. The massive sandstones of the Madrid Formation dominate the area to the northwest, while thinly interbedded pelites and siltstones occur to the southeast. These unnamed pelitic rocks are believed to be correlative with those of the Waterville Formation and would, therefore, prohibit the existence of a conformable contact between these two formations. This boundary can, therefore, only be explained by the presence of an unconformity or a major structural break. Highly disrupted structural features exhibited by the pelitic rocks adjacent to this boundary support the existence of a major fault.

Within the vicinity of Mattawamkeag, this major northeast trending fault is shown to be offset by a second, east-northeast trending fault (Plate 1). The offset produced by this second fault is supported by the distribution of the Madrid Formation to the north and south. On the northern shore of the Mattawamkeag River, intensely deformed sandstones of the Madrid Formation are exposed as far as two miles east of Mattawamkeag. To the south, these sandstones are found no further east than the eastern shore of the Penobscot River, just north of the Winn/Mattawamkeag Town line. Such a distribution cannot be achieved by the northeast trending fault without a major deviation in trend. Stratigraphic and structural orientations, therefore, favor the existence of an east-west trending offset.

Within the pelitic unit, a number of exposures exhibit characteristics suggestive of differential movement. These exposures can be traced on a northeast trending line from Medunkeunk Stream to the Mattawamkeag River, in the vicinity of Kingman (Plate 1). This fault does not produce serious dislocation of rock units and is entirely contained within the belt of unnamed pelitic rock.

A minor fault, entirely contained within the Madrid Formation, is suggested for the rocks exposed in the northernmost portion of the study area (Plate 1). Thick bedded sandstones, exposed along the Davis Farm Road, are highly fractured by two strongly developed cleavages. Other occurrences of such strong cleavage development in this lithology are only found adjacent to major faults.

STRUCTURE

Structural Features

The rocks of central and east-central Maine are characterized by large scale, upright, isoclinal folds (Osberg, 1974). Associated with these folds is a well developed northeast trending axial planar cleavage. This cleavage tends to parallel or nearly parallel bedding.

The Kingman zone is characterized by rocks which exhibit highly disrupted and chaotic structural features. The effects of deformation are best represented in the unnamed pelitic rocks where fragmented beds, dismembered folds, small scale shear zones, and mylonitic rock are common. The massive sandstone units, adjacent to this belt of dominantly pelitic rock, also record such deformation but in a more subtle fashion. Ludman (pers. comm., 1983) has noted that the structural style characterizing the Kingman zone is unlike any other seen in this region.

The attitude of bedding throughout much of this area strikes to the northeast with vertical to nearly vertical dips. Where the proportion of slate to siltstone is high, the bedding style is often complicated by the signature of deformation. Siltstone beds are commonly broken and smeared into elongate lenses of various lengths and widths. These lenses are elongate parallel to the direction of dominant cleavage or are scattered in random orientation.

At least two generations of small scale folds have been recorded within the Kingman zone. One set is represented by northeast trending hinge surfaces, while those of the other set trend nearly due north. These two sets of folds are characterized by steeply dipping to vertical hinge surfaces and moderate to steeply plunging hinge lines.

Along both the Piscataquis and Mattawamkeag Rivers, anti-clockwise and clockwise fold forms have been found. Those with a clockwise sense of rotation are, however, the most commonly occurring form at these locations and throughout the Kingman zone.

The most pervasive of all structural features is a strongly developed northeast trending cleavage. This cleavage tends to be wavy and warped and may range in orientation from N30^{o}E to N60^{o}E at a single exposure.

A somewhat less extensive but equally developed cleavage is also present within the rocks of the Kingman zone. The trend of this cleavage, although variable from N5^{o}W to N30^{o}E, is essentially north-south. The wide range in orientation for both sets of cleavage makes it difficult to distinguish between the two when they are not co-existent.

The age relationship between these two cleavages is not everywhere evident but can be distinguished at exposures along the Piscataquis and Mattawamkeag Rivers. At these two locations, crosscutting relationships provide evidence that the more northerly trending cleavage is the later of the two. On the Mattawamkeag River, in the vicinity of Kingman, a transpositional layering can be seen to parallel both sets of cleavage. The layering associated with the northeast trending cleavage is better developed and somewhat thicker than that of the other cleavage and appears axial planar to small folds. This layering is itself folded and cut by the north-south trending cleavage, which is axial planar to the second folding event.

Many of the rocks within this zone are characterized by slickensided surfaces. These surfaces trend, for the most part, to the northeast and contain gently plunging slickensides. These slickensides plunge both to the north and to the south (Fig. 5).

Structural Discussion

Evidence of deformation can be seen throughout the zone, from Kingman to Howland, but is most intensely characterized within and bordering the unnamed pelitic rocks. The exposures which exhibit features of intense deformation are located on Plate 1. The highly disrupted structural features, as well as the stratigraphic distribution, are suggestive of differential movement. These two factors define the extent and configuration of the faults depicted on Plate 1.

The dominant northeast trend of the faults is supported by the orientation of the slickensided surfaces, small scale folds and mylonitic rock contained within this area. A stereonet plot of slickensides and their associated shear planes are shown in Figure 5. The attitude of the slickensided surfaces trend to the northeast as do most of the structures in this zone. The trend and gentle plunge suggest dominately strike-slip movement along shear planes which occur at a low angle to the regional strike of the beds. This low angle relationship, between the bedding and shear planes, is a major contributor to the complexity of the region.

Shear planes and slickensides with an east-northeast trend are also depicted on Figure 5. This orientation corresponds to the east-northeast trending fault in the vicinity of Mattawamkeag.

Many of the small scale folds are characterized by northeast trending hinge surfaces and steeply plunging hinge lines. This orientation is what would be expected for folds related to faults of dominantly strike-slip movement. Folds with more northerly trending hinge surfaces are also present in the map area. These folds may quite possibly represent movement along minor faults which deviate from the major trend at a low angle.

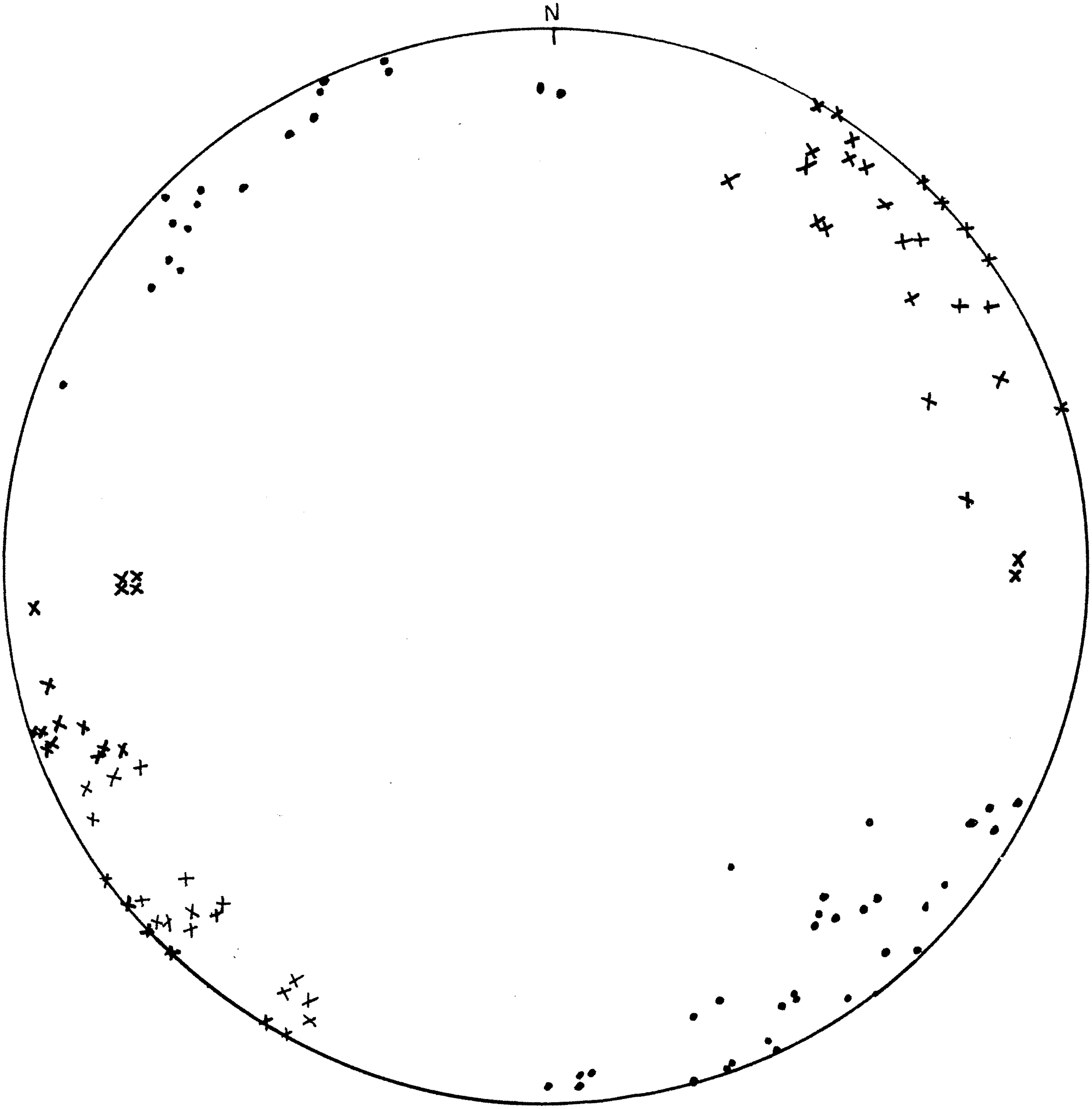

Figure 5: Stereonet plot of shear planes and slickensides, (poles to shear planes:•; trace of slickensides:x).

SUMMARY

The rocks of east-central Maine are characterized by interbedded sandstones, siltstones, and slates, of Ordovician(?) to Devonian age.

In the area between Howland and Kingman, these rocks exhibit both a lithologic distribution and structural style characteristic of differential movement. A series of northeast trending faults, with dominantly strike-slip movement, have been mapped within this area. The existence, extent and location of these faults are based on: 1) the relative position of major rock units, and 2) the highly disrupted and intensely deformed nature of the rocks.

Northeast trending linear features have also been observed in this area on both Landsat imagery photos and the Bouguer gravity map of Maine. The topographic and subsurface lineaments coincide with a zone of intense deformation within these rocks.

The pattern shown on Plate 1 is by no means a final interpretation of the stratigraphic and structural features characterizing this area. The relationships discussed within this report are based, for the most part, on field observation and preliminary laboratory analysis. A detailed study of this area is now in progress and a final report will be available at a later date.

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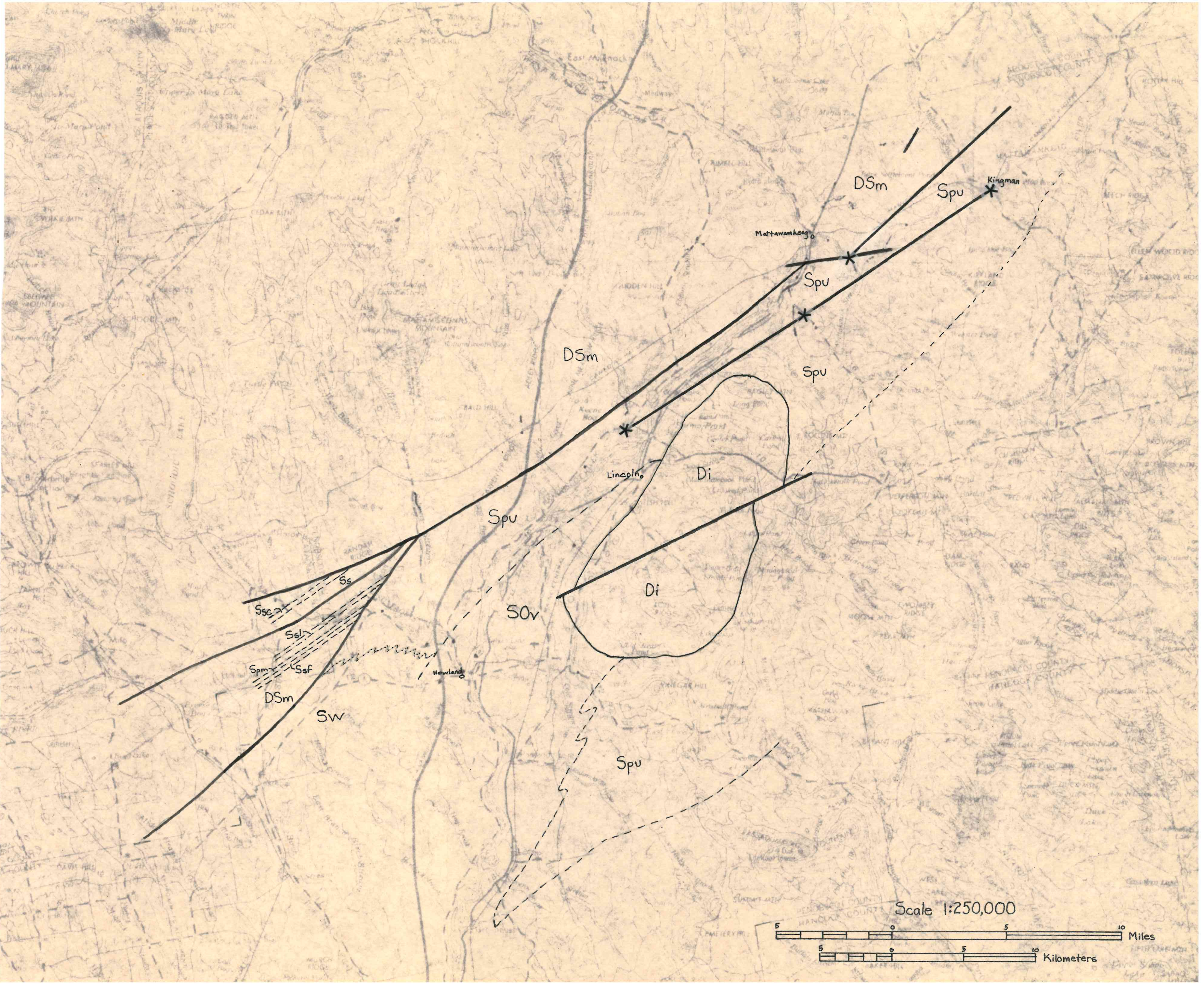
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